Severe Storm

Severe Storm

Frequency	50+ yrs	10-50 yrs	1-10 yrs	Annually
People	<1,000	1,000-10,000	10,000-50,000	50,000+
Economy	1% GDP	1-2% GDP	2-3% GDP	3%+ GDP
Environment	<10%	10-15%	15%-20%	20%+
Property	<$100M	$100M-$500M	$500M-$1B	$1B+
Hazard scale	< Low to High >			

Risk Level

- Frequency – Severe storms, which include any or a combination of: thunderstorms, hail, wind storms, lightning, or a tornado, happen annually in Washington.
- People – Looking at past history of injuries and deaths due to severe storms in Washington, the minimum threshold of a thousand injuries for this category is not met.
- Economy – According to the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center, Washington has not experienced a severe weather event that totaled losses that met or exceeded the minimum dollar amount /percentage for this category.[1]
- Environment – Severe storms do affect the environmental landscape of Washington, but their effect does not meet the minimum threshold for this category.
- Property – Severe storms can have a large impact on the property of the state, both residential and commercial. The December 2006 windstorm affected all 39 counties and the estimate for damage is still being tallied and is greater than $50 million. Total property damage from the greatest windstorm to hit Washington is estimated at $235 million (1962 dollars). This was the Columbus Day Storm of October 1962, which was the strongest non-tropical storm to ever hit the contiguous 48 states.
- Figure 5.7-1 and Figure 5.7-2 below show previous occurrences of tornado and hail events, respectively, from 1960 to 2012 as reported by the National Climatic Data Center. It should be noted that the entire state is vulnerable to the severe storm hazard, including winds, lightning, snow, tornadoes, and hail, due to its atmospheric nature.

Figure 5.7-1 The severe storm element tornado was collected from the National Climatic Data Center website for the period of 1954-2012. Tornadoes for these years were in the value of F-0 to F-3 (Fujita Scale) or EF-0 to EF-1 (Enhanced Fujita) if recorded after Jan. 2007.

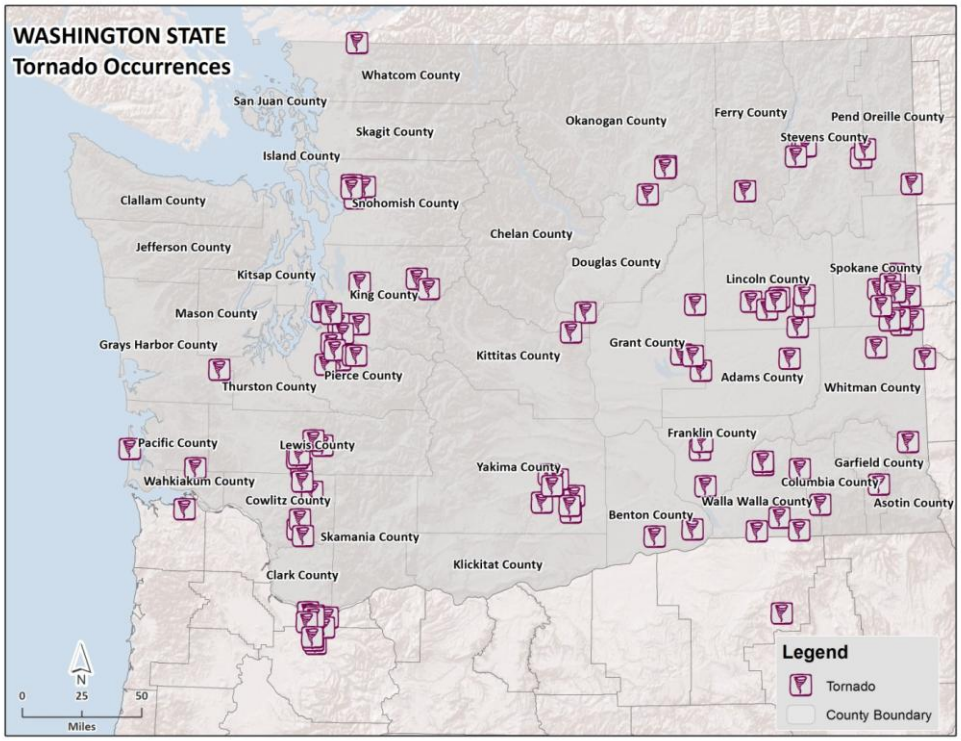
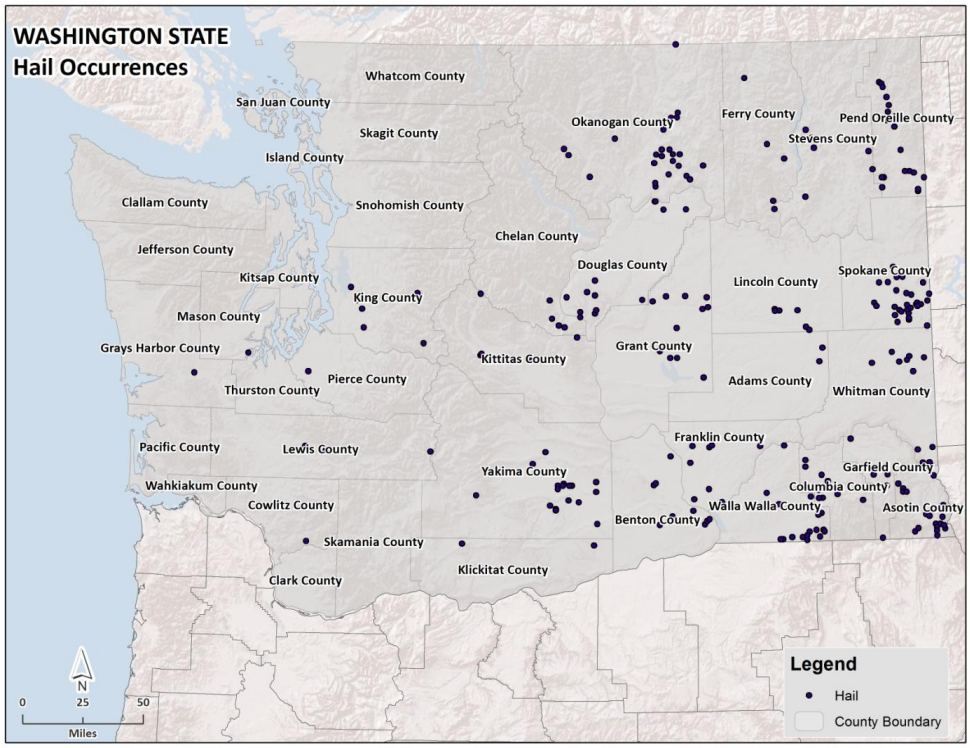


Figure 5.7-2 The severe storm element hail was collected from the National Climatic Data Center website for the period of 1955-2012. Hail for these years ranged in diameter from ½ to 2 inches.



Summary[2]

The hazard – For the purposes of this assessment, a Severe Storm is defined as an atmospheric disturbance featuring sustained strong winds (40+ MPH) and/or significant precipitation (rain or snow). Such events typically occur during the winter months and generally move into the State from the Pacific Ocean. They may include any or a combination of: thunderstorms, hail, wind storms, lightning, or tornadoes.

Previous occurrences – According to the National Weather Service, events meeting the Severe Storm definition have produced some of the most significant weather events in the 20th Century in Washington State, including snowstorms in January 1916 and January 1950; the Columbus Day Windstorm in October, 1962 (still the most dramatic weather ever to hit the State); the Inauguration Day Windstorm in January, 1993; the January 1997 Winter Storm; the December 2006 Hanukkah Eve Windstorm; the December 2007 windstorm and flood; the December 2008 snow storms; the January 2009 floods; the 2011 January ice storm; and the 2012 Ferry County wind storm. Many of these events have resulted in a presidential disaster declaration, emphasizing their severity. These events are described in detail below.

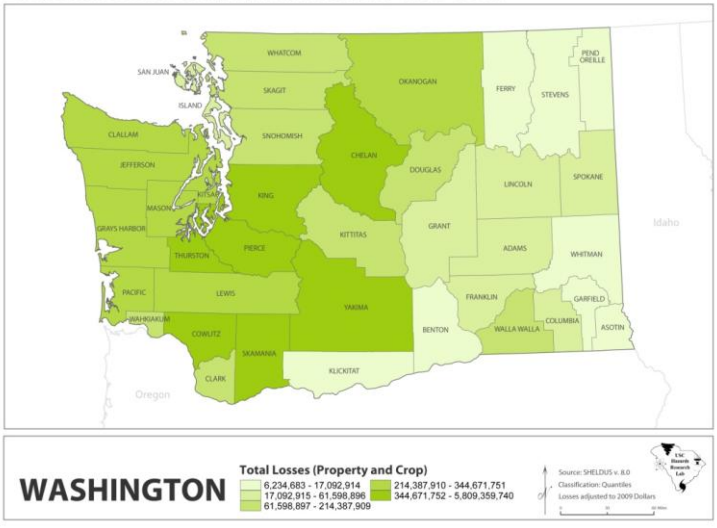
Probability of future events - Because of its location on the windward coast of the North Pacific Ocean and its mountainous topography which influences precipitation patterns, Washington State is assured of powerful Severe Storm events in the future.

Jurisdictions at greatest risk – While Severe Storms have impacted every corner of the State, counties most at risk include those along the Pacific Coast, counties within the Puget Sound basin, counties along the east slopes of the Cascade Mountains, and some counties in southeastern Washington as well as Spokane County.

Special note – This profile will not attempt to estimate potential losses to state facilities due to severe storm. The state does not have data on which to base a determination of which facilities might be most vulnerable to either high winds or winter storm. However, all facilities are considered at risk to this hazard.

Figure 5.7-3 shows the economic losses from all weather-related hazard damage (including property, timber, and crops) from 1960-2009

Economic Losses from Hazard Events, 1960-2009



The Hazard [3]

All areas of Washington State are vulnerable to severe weather. Typically, a severe storm can cause major impacts to transportation, infrastructure and services, and loss of utilities. Most storms move into Washington from the Pacific Ocean. A severe storm is defined as an atmospheric disturbance that results in one or more of the following phenomena: high winds, heavy snow, large hail, thunderstorms, lightning, tornados, rain, snow or other mixed precipitation. These phenomena are defined by the National Weather Service:

- **High Winds** – Sustained wind speeds of 40 mph or greater lasting for 1 hour or longer, or winds of 58 mph or greater for any duration, not caused by thunderstorms.
- **Severe Thunderstorm** – A thunderstorm that produces a tornado, winds of at least 58 mph (50 knots), and/or hail at least 1 inch in diameter. A thunderstorm with wind equal to or greater than 40 mph (35 knots) and/or hail at least ½ inches in diameter is defined as approaching severe.
- **Tornado** – A violently rotating column of air, usually pendant to a cumulonimbus (type of cloud), with circulation reaching the ground. It nearly always starts as a funnel cloud and may be accompanied by a loud rotating noise. On a local scale, it is the most destructive of all atmospheric phenomena.
- **Heavy Snow** – This generally means: a snowfall accumulating to 4" or more in depth in 12 hours or less or a snowfall accumulating to 6" or more in depth in 24 hours or less.
- **Lightning** – A visible electrical discharge produced by a thunderstorm. The discharge may occur within or between clouds, between the cloud and air, between a cloud and the ground or between the ground and a cloud.
- **Hail** – Showery precipitation in the form of irregular pellets or balls of ice more than 5 mm in diameter, falling from a cumulonimbus cloud.
- **Winter storm** – A storm with significant snowfall, ice, and/or freezing rain; the quantity of precipitation varies by elevation. Heavy snowfall is 4 inches or more in a 12-hour period, or 6 or more inches in a 24-hour period in non-mountainous areas; and 12 inches or more in a 12-hour period or 18 inches or more in a 24-hour period in mountainous areas.

Note: Although flooding is a result of severe rainstorms, see Tab 5 "Flood" for a separate profile on the flood hazard.

Hazardous Weather Seasons[4]

The primary flood season in Western Washington (west slops of Cascades) is November through February while the primary flood season in Eastern Washington (east slopes of Cascades) is May and June. The windstorm season for the state is October through March. The snow season in western Washington is mid November through mid March while the snow season for Eastern Washington is November through March. The snow season for the state's mountains is mid October through May.

Washington State's Climate[5]

The location of the State of Washington on the windward coast in mid-latitudes is such that climatic elements combine to produce a predominantly marine-type climate west of the Cascade Mountains while east of the Cascade Mountains, the climate possesses both continental and marine characteristics.

The state's climate is impacted by two significant factors:

- Mountains. The Olympic Mountains and the Cascade Mountains affect rainfall. The first major release of rain occurs along the west slopes of the Olympics, and the second is along the west slopes of the Cascade Range. Additionally, the Cascades are a topographic and climatic barrier.

Air warms and dries as it descends along the eastern slopes of the Cascades, resulting in near desert conditions in the lowest section of the Columbia Basin in eastern Washington. Another lifting of the air occurs as it flows eastward from the lowest elevations of the Columbia Basin toward the Rocky Mountains. This results in a gradual increase in precipitation in the higher elevations along the northern and eastern borders of the state.

- Location and intensity of semi-permanent high and low-pressure areas over the North Pacific Ocean.
    - During the summer and fall, circulation of air around a high-pressure area over the North Pacific brings a prevailing westerly and northwesterly flow of comparatively dry, cool and stable air into the Pacific Northwest. As the air moves inland, it becomes warmer and drier, resulting in a dry season.
    - In the winter and spring, the high pressure resides further south while low pressure prevails in the Northeast Pacific. Circulation of air around both pressure centers brings a prevailing southwesterly and westerly flow of mild, moist air into the Pacific Northwest. Condensation occurs as the air moves inland over the cooler land and rises along the windward slopes of the mountains. This results in a wet season beginning in late October or November, reaching a peak in winter, gradually decreasing by late spring.

West of the Cascade Mountains, summers are cool and relatively dry while winters are mild, wet and generally cloudy. Generally, in the interior valleys, measurable rainfall occurs on 150 days each year and on 190 days in the mountains and along the coast. Thunderstorms over the lower elevations occur up to 10 days each year and over the mountains up to 15 days. Damaging hailstorms rarely occur in most localities of western Washington. During July and August, the driest months, two to four weeks can pass with only a few showers; however, in December and January, the wettest months, precipitation is frequently recorded on 20 to 25 days or more each month.

The range in annual precipitation is from about 20 inches in an area northeast of the Olympic Mountains to 150 inches along the southwestern slopes of these mountains. Snowfall is light in the lower elevations and heavy in the mountains. During the wet season, rainfall is usually of light to moderate intensity and continuous over a period of time, rather than heavy downpours for brief periods; heavier intensities occur along the windward slopes of the mountains.

The strongest winds are generally from the south or southwest and occur during the fall and winter. In interior valleys, sustained wind velocities usually reach 40 to 50 mph each winter, and 75 to 90 mph a few times every 50 years. The highest summer and lowest winter temperatures generally occur during periods of offshore easterly winds.

The climate east of the Cascade Mountains has characteristics of both continental and marine climates. Summers are warmer, winters are colder, and precipitation is less than in western Washington. Extremes in both summer and winter temperatures generally occur when air from the continent influences the inland basin.

In the driest areas, rainfall occurs about 70 days each year in the lowland and about 120 days in the higher elevations near the eastern border and along the eastern slopes of the Cascades. Annual precipitation ranges from seven to nine inches near the confluence of the Snake and Columbia Rivers in the Tri-Cities area, 15 to 30 inches along the eastern border and 75 to 90 inches near the summit of the Cascade Mountains. During July and August, four to eight weeks can pass with only a few scattered

showers. Thunderstorms, most as isolated cells, occur on one to three days each month from April through September. A few damaging hailstorms are reported each summer.

During the coldest months, freezing drizzle occasionally occurs, as does a Chinook wind that produces a rapid rise in temperature. During most of the year, the prevailing wind is from the southwest or west. The frequency of northeasterly winds is greatest in the fall and winter. Sustained wind velocities ranging from four to 12 mph can be expected 60 to 70 percent of the time; 13 to 24 mph, 15 to 24 percent of the time; and 25 mph or higher, 1 to 2 percent of the time. The highest wind velocities are from the southwest or west and are frequently associated with rapidly moving weather systems. Extreme sustained wind velocities can be expected to reach 50 mph at least once in two years; 60 to 70 mph once in 50 years; and 80 mph once in 100 years.

Previous Occurrences

Washington has had several notable severe storm events in its history including severe snowstorms, tornadoes and windstorms. The most notable snowstorm in Washington to date occurred during January and February of 1916. On February 1, 1916, Seattle recorded a record snowfall accumulation of 21.5 inches in a 24-hour period. Other parts of Washington received around 2 to 4 feet of snow for the entire winter.

Although far from the famous "tornado alley" of the Midwest United States, Washington has tornadoes. Washington's deadliest tornado outbreak occurred on April 5, 1972. On this day, an F-3 tornado (sustained winds of 158-206 mph) touched down in the City of Vancouver causing 6 deaths, 300 injuries and an estimated $50 million in damage. Later that same day, another F-3 tornado touched down west of Spokane in rural Lincoln County and an F-2 tornado (sustained winds of 113-157 mph) struck rural Stevens County. The state experienced another outbreak of tornadoes on May 31, 1997. On this day, a record six tornadoes touched down in Washington: four F-1 tornadoes (sustained winds of 73-112 mph) struck in Stevens and Spokane Counties and an additional two F-0 tornadoes (sustained winds of 40-72 mph) touched down, one in Vancouver and one in Tacoma. Besides tornadoes, these severe storms produced large hail up to 3 inches in diameter with heavy rain and wind gusts up to 80 mph.

Windstorms occur more often than tornadoes in Washington and cause millions of dollars in damage with each occurrence.

- The Columbus Day Windstorm that hit the Northwest on October 12, 1962 is the greatest windstorm to strike this area and has become the windstorm of which all others are compared. This storm was the strongest widespread non-tropical windstorm to hit the continental U.S. during the 20th century, with its effects felt from northern California to British Columbia. The storm claimed 46 lives and caused the loss of power to over 1 million homes. More than 50,000 homes were damaged costing an estimated $235 million (1962 dollars).
- The Inauguration Day Windstorm on January 20, 1993 (Federal Disaster #981) brought hurricane force winds (sustained winds or gusts of 74 mph or greater) to King, Mason, Lewis, Thurston, Snohomish, Pierce, and Wahkiakum Counties. This storm claimed 5 lives and resulted in the destruction of 52 homes and damaged an additional 249 homes and 580 businesses. Total damage resulting from this storm is estimated at $130 million.
- The most powerful windstorm since the 1993 storm occurred in December of 2006 (Federal Disaster #1682) (Figure 5.7-2). This storm brought 90 mile per hour winds to Washington's coastline and wind gusts of up to 70 mph in the Puget Sound region. The storm also knocked out power to 1.5 million Washington residents with some not seeing electricity restored for 11

days. A federal disaster declaration was declared for all 39 of Washington's counties and estimated damages exceeded $50 million dollars.

- A windstorm on July 20, 2012 hit Okanogan and Ferry Counties plus the Confederated Tribes of the Colville Reservation in eastern Washington (Federal Disaster #DR-4083). Damage estimates were at $8.4 million for Ferry County and $1.1 million for Okanogan County

Figure 5.7-4 Affects of December 2006 Windstorm. One of the may damaged homes resulting from falling trees due to strong winds from the storm.

Significant Severe Storms in Washington State – 1900 to Present

January/February 1916 – Seattle's Greatest Snowstorm[6] - One of the top 10 weather events in Washington State during the 20th Century according to the National Weather Service, Seattle Forecast Office. Seattle's snowfall in January was 23 inches, and February snowfall was 35 inches, for a two-month total of 58 inches. Seattle recorded its maximum snowfall ever in a 24-hour period, with 21.5 inches on February 1. Other parts of western Washington received between two to four feet of snow. Winds created snowdrifts as high as five feet. The region was crippled, with transportation essentially halted.

May/June 1948 – Greatest Spring Snowmelt Flooding[7] -One of the top 10 weather events in Washington during the 20th Century according to the National Weather Service, Seattle Forecast Office. Snowmelt flooding broke lake and river records in Eastern Washington and along the Columbia River to the Pacific Ocean. Flood lasted 45 days. Vancouver, Camas, Kalama, and Longview suffered flood damage.

January 13, 1950 – The January 1950 Blizzard[8] - One of the top 10 weather events in Washington during the 20th Century, according to the National Weather Service, Seattle Forecast Office. On this date, 21.4 inches of snow fell in Seattle, the second greatest 24-hour snowfall recorded. The snowfall was accompanied by 25-40 mph winds. The storm claimed 13 lives in the Puget Sound area. January had 18 days with high temperatures of 32 degrees or lower. The winter of 1949-50 was the coldest winter on record in Seattle, with an average temperature of 34.4 degrees. Eastern Washington, North Idaho, and parts of Oregon also were paralyzed by the snow – some lower-elevation snow depths reached nearly 50 inches and temperatures plunged into minus teens and twenties. Several dozen fatalities occurred.

October 12, 1962 – The Columbus Day Wind Storm[9, 10]- The top weather event in Washington during the 20th Century, according to the National Weather Service, Seattle Forecast Office. This storm is the greatest windstorm to hit the Northwest since weather recordkeeping began in the 19th century, and called the "mother of all wind storms" in the 1900s. All windstorms in the Northwest are compared to this one. The Columbus Day Storm was the strongest widespread non-tropical windstorm to strike the continental U.S. during the 20th century, affecting an area from northern California to British Columbia.

The storm claimed seven lives in Washington State; 46 died throughout the impacted region. One million homes lost power. More than 50,000 homes were damaged. Total property damage in the region was estimated at $235 million (1962 dollars). The storm blew down 15 billion board feet of timber worth $750 million (1962 dollars); this is more than three times the timber blown down by the May 1980 eruption of Mount St. Helens, and enough wood to replace every home in the state.

Highest recorded wind speeds (before power went out at recording stations) were Naselle, Washington Coast – gust to 160 mph; Bellingham and Vancouver – gusts of 113 mph; Renton – gust of 100 mph; and Tacoma – gust of 88 mph.

April 5, 1972 – Washington's Deadliest Tornado Outbreak[11, 12] - One of the top 10 weather events in Washington during the 20th Century, according to the National Weather Service, Seattle Forecast Office. Three tornadoes touched down in Washington State on this day: An F3 tornado touched down in Vancouver; it swept through a grocery store, bowling alley, and grade school near where Vancouver Mall is today. It caused six deaths, 300 injuries, and $50 million in damage. Later that day, another F3 tornado touched down west of Spokane near Davenport, and an F2 tornado struck rural Stevens County. Numerous severe thunderstorms with large hail and damaging winds were reported over other areas of eastern Washington. An F3 tornado (prior to 2008) has winds of 158-206 mph, and is capable of severe damage. An F2 tornado has winds of 113-157 mph and is capable of considerable damage. Because of these tornados, Washington led the nation in tornado deaths in 1972.

December 1982 [13] - Federal Disaster #676. Disaster assistance provided – $1.7 million. Small Business Administration loaned $1 million to home and business owners for damages. Severe storm and coastal flooding affected Whatcom County. Four persons injured and 122 people evacuated; 129 homes and 113 businesses damaged; and $1.7 million in public facility damage.

November 1990 – Statewide Flooding[14, 15]- Federal Disaster #883. Stafford Act disaster assistance provided – $57 million. One of the top 10 weather events in Washington during the 20th Century according to the National Weather Service, Seattle Forecast Office. Widespread, major flooding on western Washington rivers and several eastern Washington rivers. This storm caused two deaths. Damage estimated at $250 million. The Interstate 90 Lake Washington floating bridge between Seattle and Mercer Island sank during this storm event.

December 1990 – Severe Storm - Federal Disaster #896. Stafford Act disaster assistance provided – $5.1 million. Floods, snow, and high winds affected the counties of Island, Jefferson, King, Kitsap, Lewis, Pierce, San Juan, Skagit, Snohomish, and Whatcom.

January 20, 1993 – The Inauguration Day Wind Storm[16, 17] - Federal Disaster #981. Stafford Act disaster assistance provided – $24.2 million. Hurricane force winds swept King, Lewis, Mason, Pierce, Snohomish, Thurston and Wahkiakum counties. This storm claimed five lives. More than 870,000 homes and businesses lost power. Fifty-two single-family homes, mobile homes, and apartment units were destroyed and 249 incurred major damage, many from falling trees and limbs. More than 580 businesses were damaged. Total damage in western Washington estimated at $130 million. Winds in Puget Sound area gusted to 70 mph. A gust at Cape Disappointment on the Washington Coast reached 98 mph.

February 1996 – Storm with Widespread Flooding, Snowmelt, Mudslides in Washington, Oregon, and Idaho[18, 19] - Federal Disaster #1100. Stafford Act disaster assistance provided – $113 million. Small Business Administration disaster loans approved - $61.2 million. One of the top 10 weather events in Washington during the 20th Century according to the National Weather Service, Seattle Forecast Office. Heavy rainfall, mild temperatures and snowmelt caused flooding and mudslides in Adams, Asotin, Benton, Clark, Columbia, Cowlitz, Garfield, Grays Harbor, King, Kitsap, Kittitas, Klickitat, Lewis, Lincoln, Pierce, Skagit, Skamania, Snohomish, Spokane, Thurston, Wahkiakum, Walla Walla, Whitman and Yakima counties, and the Yakama Indian Reservation. This storm caused major flooding on rivers of

western and southeast Washington. Mudslides occurred throughout the state. Three deaths and 10 people were injured. Nearly 8,000 homes damaged or destroyed. Traffic flow - both east and west, and north and south, along major highways - was shut down for several days. An avalanche closed Interstate 90 at Snoqualmie Pass. Mudslides in Cowlitz County and flooding in Lewis County closed Interstate 5. Damage throughout the Pacific Northwest estimated at $800 million.

November 1996 – Spokane Area Ice Storm[20, 21] - Federal Disaster #1152. Stafford Act disaster assistance provided – $11.9 million. Heavy rain, freezing rain and snow fell in Spokane, Pend Oreille, and Klickitat counties. Up to three inches of ice was deposited on trees, vehicles, buildings, etc., across much of the populated areas of Spokane County. More than 100,000 homes and businesses lost power; some were without power for up to nine weeks. Power outage affected water and sewage pumping systems. Spokane International Airport was closed for two days due to power outage. Four people died and damage estimated at more than $22 million dollars.

December 1996 - January 1997 – Ice, Wind, Flooding, Snowloading, Landslides[22] - Federal Disaster #1159. Stafford Act disaster assistance provided – $83 million. Small Business Administration loans approved – $31.7 million. Saturated ground combined with snow, freezing rain, rain, rapid warming and high winds within a five-day period produced flooding and landslides. Impacted counties – Adams, Asotin, Benton, Chelan, Clallam, Clark, Columbia, Cowlitz, Douglas, Ferry, Franklin, Garfield, Grant, Grays Harbor, Island, Jefferson, King, Kitsap, Kittitas, Klickitat, Lewis, Lincoln, Mason, Okanogan, Pacific, Pend Oreille, Pierce, San Juan, Skagit, Skamania, Snohomish, Spokane, Stevens, Thurston, Walla Walla, Whatcom, and Yakima. Twenty-four deaths; $140 million (est.) in insured losses; 250,000 people lost power. There were more than 130 landslides between Seattle and Everett, primarily along shorelines. Interstate 90 at Snoqualmie Pass was closed due to avalanche.

May 31, 1997 – Tornado Outbreak[23, 24] - A record six tornados touched down in Washington in one day; the state's previous record was four tornados in 1989 for the entire year. Four F1 tornados hit Stevens and Spokane counties in northeast Washington. Two F0 tornados touched down in western Washington – Vancouver and Tacoma. Also, on the same day in Idaho, an F1 tornado struck Athol and an F0 was observed near Lewiston. In addition, this storm produced severe thunderstorms with large hail up to two to three inches in diameter, heavy rain and flash flooding, and wind gusts to near 80 mph. An F0 tornado has winds of 40-72 miles per hour and is capable of light damage. An F1 tornado has winds of 73-112 mph and is capable of moderate damage. No deaths or injuries reported. A record 14 tornados were reported in the state in 1997.

December 14-15 2006 Windstorm. Federal Disaster # 1682. The powerful windstorm slammed into Washington State with 90 MPH winds on the Coast, gusts up to 70 MPH in the Puget Sound basin, and peak winds well over 100 MPH along the Cascade Crest. Up to 1.5 million residents were without power for up to 11 days. The storm resulted in 15 deaths (including 8 from carbon monoxide poisoning). Governor Gregoire proclaimed an emergency for all 39 Counties. Total damages exceeded $50 million dollars.

December 1-17 2007 Severe Storm. Federal Disaster # 1734. A major disaster declaration was issued for 10 counties for Individual Assistance and 12 counties for Public Assistance, the latter comprised of Clallam, Grays Harbor, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Skagit, Snohomish, Thurston and Wahkiakum counties.

During the time period December 1-3, 2007, three storms moved over the Pacific Northwest. December 1st marked the first in the series, producing heavy snow in the mountains and low-land snow throughout

western Washington. Snow fall levels ranged from a trace to 1" in Seattle, to many areas away from Puget Sound receiving over 4". On December 2nd, the snow changed over to rain as temperatures increased, accompanied by strong winds. As a low pressure system moved over the Olympic Peninsula, wind gusts of over 80 mph were observed along much of the coast (Hoquiam 81, Destruction Island 93, Tatoosh Island 86) and over 40 mph inland (Olympia 44, Seattle 48, Bellingham 53).

During this same storm series, a windstorm packing hurricane force winds battered the coasts of Washington and Oregon during December 1-3, 2007. Winds with this storm were second only to that of the 1962 Columbus Day Storm with a recorded gust of 102 mph at Klipsan Beach on the Long Beach Peninsula. Another report of 146 mph was also received from a communication tower at an elevated site (~1500 feet) near radar ridge in Pacific County. These strong winds caused extensive power and communication outages that lasted up to 4 days. The longevity of the strong winds, lasting up to 36 hours made this storm very unique and was responsible for much of the damage. This storm also delivered significant wave heights (top 1/3 of wave heights) of 44 to 48 feet in the offshore waters before unmooring the buoys that were observing them.

The most significant of the three storms arrived December 3rd, with near record high temperatures (59°F for Seattle) and moist tropical air which led to record rainfall and flooding around western Washington. Reports indicated that 6-hour and 24-hour precipitation amounts were at or near 100-year rain frequency levels. For Sea-Tac Airport, December 3, 2007 became the 2nd wettest day on record with 3.77" (first is 4.93" recorded on October 20, 2003) and the wettest day on record for Bremerton which received 7.50" of rain, breaking the old record of 5.62" set December 10, 1921. Several sites reached all time record high river flows and set all-time record high flood stage levels, including the Chehalis River, which reached nearly 75 ft (10 feet over flood stage), breaking the previous record set in the floods of February 1996. The flooding of the Chehalis River led to widespread flooding throughout western Lewis County, including a stretch of I-5, forcing 20 miles of the interstate to be closed for 4 days. The Coast Guard rescued more than 300 people from the flood areas, and the flooding and mudslides resulted in at least 5 deaths.

January 6-8, 2009 Severe Winter Storms, Landslides, Mudslides, and Flooding - Federal Disaster No 1817[25]. A strong, warm and very wet Pacific weather system brought copious amounts of rainfall to Washington during the period 6-8 January, 2009, with subsequent major flooding extending through January 11, 2009, as well as minor flooding that continued through most of January. The storm involved a strong westerly flow aloft with embedded sub-tropical moisture, known as an *atmospheric river* of moisture. Snow levels rose from near sea level to between 6,000 and 8,000 feet, with strong westerly winds enhancing precipitation amounts in the mountains. Antecedent conditions from a mid-December through early January region-wide cold snap and associated heavy snow helped set the stage for flooding. This event also produced avalanches in the mountains, and caused more than an estimated 1,500 land/mudslides across the state, and resulted in structural damage to buildings from added snow load, compounded by heavy rains.

All counties of Western Washington lowlands received 3-8 inches of rain, while east of the Cascades, amounts ranged from 2 to 7.5 inches. On January 7, 2009, Olympia set a daily record with 4.82 inches. The National Weather Service issued flood warnings for 49 flood warning points across the state. Some daily rainfall records were broken on January 7th at airports: Sea-Tac saw 2.29 inches that broke 1.33 inches on January 7th in 1996, Olympia saw 4.82 inches breaking 1.95 set on January 7, 2002, and Quillayute saw 2.88 inches breaking 2.39 set on January 7, 1983.

Emergency Alert System was activated by NWS Seattle and Portland as 22 Western Washington rivers exceeded *major* flood category. Two rivers, the Naselle in Pacific County and the Snoqualmie reached all-time record crests. Six rivers had near-record crests, while Mud Mountain Dam and Howard Hanson Dam had record levels of inflows. The State's primary north-south rail line was also closed. Interstate-5 was closed from milepost 68 to 89 for 43 hours due to water over the roadway around Chehalis. The economic impact of this closure was estimated at $12 million per day. Public Assistance was provided to 22 counties, while Individual Assistance was provided to 15 counties.

January 11 – 21, 2011 Severe Winter Storm, Flooding, Landslide and Mudslides. Federal Disaster #1963.[26] According to NOAA's National Climatic Data Center, "A cold easterly wind through the Columbia River Gorge was keeping cold air trapped in the Gorge as a strong Pacific frontal system moved inland. This system spread precipitation over the Gorge starting as snow and changing over to freezing rain as the air mass warmed." This storm was marked largely by icing damages. Public Assistance was granted to King County, Kittitas County, Klickitat County, Lewis County, Skagit County, Skamania County and Wahkiakum County. The Preliminary Damage Assessment report indicated nearly $8.7 million in damages. Countywide per capita impact (based on 2000 demographic data) was as follows: Countywide per capita impact: King County ($3.57), Kittitas County($20.30), Klickitat County ($8.19), Lewis County ($9.42), Skagit County ($6.85), Skamania County ($22.49), and Wahkiakum County ($21.71).

January 14 -24, 2012 Severe Winter Storm, Flooding, Landslide and Mudslides. Federal Disaster #4056.[27] This winter storm 'Snowmageddon' disrupted airport traffic, closed roads and schools, downed trees resulting in tons of debris blocking roads and knocked out power to more than 275,000 customers across the state. According to the National Climatic Data Center, "arctic air moved into the region followed by a series of moderate to strong upper level storm systems riding on a moist subtropical jet stream. The result was widespread heavy snow and local high winds." Damage estimates of over $32million were reported in the Preliminary Damage Assessment document.[28] Public Assistance was granted to 11 counties: Clallam, Grays Harbor, King, Klickitat, Lewis, Mason, Pierce, Skamania, Snohomish, Thurston, and Wahkiakum. The per capita damage estimates in each of these counties is as follows: Countywide per capita impact according to the Preliminary Damage Estimate is as follows: Clallam County ($3.57), Grays Harbor County ($7.21), King County ($3.97), Klickitat County ($113.46), Lewis County ($13.86), Mason County ($9.72), Pierce County ($12.87), Skamania County ($83.72), Snohomish County ($7.72), Thurston County ($13.00), and Wahkiakum County ($3.49) (based on 2000 demographic data). These damages resulted in a statewide per capita impact of $1.35. Over 800 recovery projects were applied for as a result of the storm.

July 20, 2012 Severe Storm, Straight-line Winds, Flooding. Federal Disaster #4083.[29] Public Assistance was made available to Ferry and Okanogan Counties and the Confederated Tribes of the Coleville Reservation. Damage was largely a result of fallen trees onto structures and power lines. This event was carried wind bursts exceeding 100 miles per hour that resulted in extensive property damage and power disruption. One fatality was reported in Ferry County and dozens of structures (including homes) were damaged.

According the National Climatic Data Center (NCDC), this was one of the most widespread severe weather events to occur across the Spokane County Warning area.[30] The details of the event from NCDC follow: A combination of afternoon heating and smaller impulses ejecting from the offshore low kept the region very unsettled with several rounds of severe thunderstorms from the 15th through the 19th. On the morning of the 20th, the remnants of Tropical Storm Fabio became ingested into the southerly flow and moved toward the region. Meanwhile, a shortwave dropping into the Gulf of Alaska acted to kick the upper-low off the southwestern Oregon Coast inland. The upper-level wave took on a strong

negative tilt, driven northeastward by a 75 knot jet streak, crossing through Eastern Washington during the early to late afternoon on July 20th. The combination of strong dynamic forcing along the shortwave, presence of an abnormally moist, unstable air mass, time of day, highly diffluent flow aloft, and jet streak dynamics led to numerous severe thunderstorms across Eastern Washington. Severe hail, winds, and flash flooding were observed with storms during the early afternoon but the threat transitioned to severe winds by the mid to late afternoon as storms migrated into the Northeastern Mountains. These storms blew down hundreds of trees causing one fatality. Ferry and Okanogan Counties were the hardest hit counties and experienced power outages in some remote communities in excess of one week. Consequently, state and federal assistance was necessary.

Preliminary damage figures for Ferry County estimated $2.6 million in debris removal, $1.6 million in emergency protective measures, $128,000 for road and bridge repair, $570,000 to building and equipment, $3.2 million for utility repair, and $163,000 for parks and recreation. Seven thousand people lost power in Ferry County and three major roads were closed for sometime due to downed trees. These roads included Highways 21, 97, and 155. Utility companies estimated 200 downed power poles and 40 miles of line needed restoration. In Okanogan County, estimations of $82,000 in debris removal, $36,000 in emergency protective measures, $180,000 for road and bridge repair, $419,000 to building and equipment, $364,000 for utility repair, and $25,000 for parks and recreation. Cumulative figures indicated a total of $8.4 million for Ferry County and $1.1 million for Okanogan County. Some reports stated that private weather instruments at residents' houses recorded winds between 80 and 100 miles per hour.

Summary of Impacts of Hazardous Weather in Washington State – 1995 to 2012[31]

Year	Fatalities	Injuries	Property Damage	Crop Damage	FEMA Disaster Number
1995	3	2	$10.3 million	not listed	
1996	13	34	$63.9 million	$5.7 million	#1100, #1152, and #1159
1997	26	21	$23.6 million	$900,000	
1998	4	15	$22.9 million	$85.4 million	
1999	6	15	$39.7 million	$300,000	
2000	3	21	$11.2 million	$100,000	
2001	11	19	$7.6 million	$95.5 million	
2002	5	12	$14.5 million	$90.3 million	
2003	4	37	$31.3 million	not listed	
2004	1	10	$6.4 million	$5.5 million	
2005	4	23	$14.5 million	$100.3 million	
2006	5	58	$171.7 million	$69.7 million	#1682
2007	15	19	$197.28 million	$20,000	#1734
2008	7	5	$31.78 million	$105 million	#1817
2009	4	4	$123.93 million	$10,000	
2010	2	8	$11 million	$90,000	
2011	6	5	$18.82 million	$680,000	
2012*	N/A	N/A	N/A	N/A	#4056 #4083, and #1963
Totals	**119**	**308**	**$800.41 million**	**$559.5 million**	

*As of February 22, 2013, 2012 data from the National Weather Service was not available for inclusion in this edition. The NOAA National Climatic Data Center was also consulted for 2012 data. No deaths, injuries or property damage were reported for winter storms, high wind or thunderstorm wind. *Severe storms that resulted in flooding are described in more detail in the Flood hazard profile*

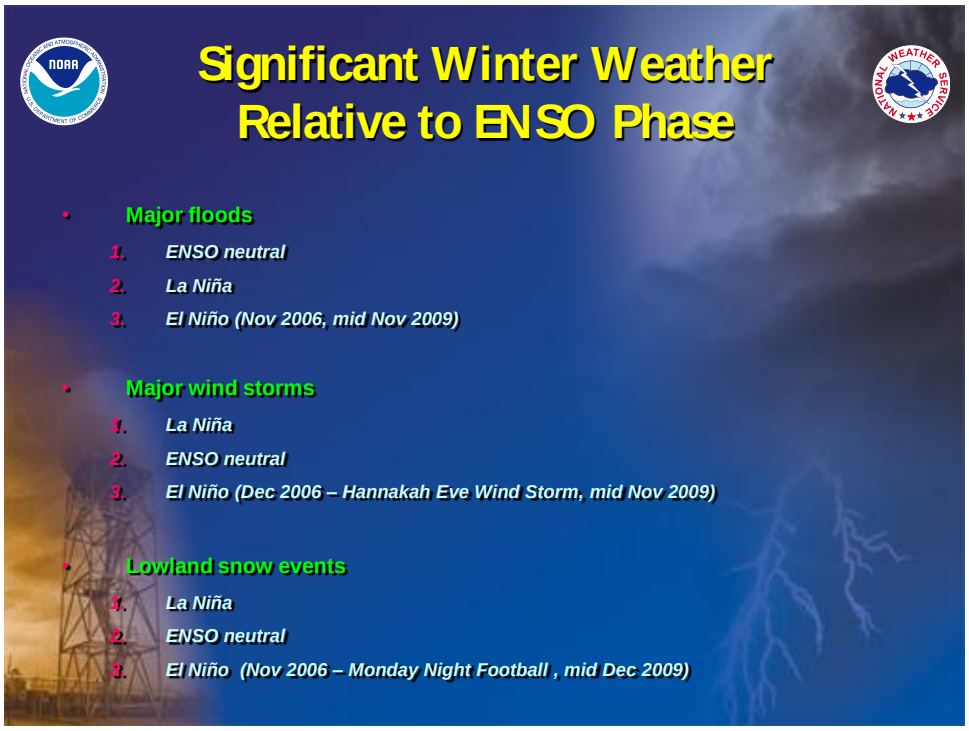
An associated event associated with winds the bears monitoring are dust storms. Several dust storms have occurred in recent years like the October 4, 2009 and May 3, 2010 events in eastern Washington captured by NASA Earth Observatory's Moderate Resolution Imaging Spectroradiometer (MODIS) available at http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=40590. In 2009, visibility dropped to zero in parts of eastern Washington as a large dust storm blew through. The storm brought strong winds gusting to 43 miles per hour in places that propelled the dust across the southeast corner of the state. After numerous multi-vehicle accidents, sections of Interstate 90 near the town of Moses Lake and several local roads had to be closed for several hours. Dryland farmers rely entirely on rainfall to sustain their crops, and as a result, do many things to preserve moisture in the soil. Some of these practices—leaving a field fallow after harvest to allow water to build in the soil for a year or covering the field with dry soil to prevent underlying moisture from evaporating—make dryland agriculture very prone to dust storms. These fields are likely either fallow or newly planted, probably with winter wheat, a common dryland crop in eastern Washington. The dust storm persisted for several hours. In 2010, the dust was rising from farmland in Central Washington where crops are not yet growing. The winds were blowing at 40 miles per hours. The winds blew the dust across the state, forcing several roads to close because of low visibility. No events have been reported since the 2010 event. However, continuing climate change may make Washington more vulnerable to dust storms.

Unrelated but still relevant is Space Weather because of its ability to disrupt radio communications networks including cellular systems, satellites, Global Positioning Systems (GPS), power grids, and aviation. Space weather comes in the form of radio blackouts, solar radiation storms, and geomagnetic storms caused by solar disturbances from the Sun. Alone, space weather can be a nuisance but combined with an evolving disaster event, it could significantly impact response and recovery efforts. Currently, NOAA National Weather Service Space Weather Prediction Center provides watches, alerts and warnings, plus educational tools at http://www.swpc.noaa.gov/.

Probability of Future Events

Based on a Ted Buehner, Warning Coordination Meteorologist, National Weather Service, Seattle Forecast Office, presentation to Washington State Emergency Management on October 25, 2012 using National Climate Prediction Center forecasts and his personal experience as a meteorologist in the northwest, severe storms can occur in any given winter regardless of the El Nino Southern Oscillation (ENSO) phase. However, some general trends can be teased out as depicted in the presentation slide below (Figure 5.7-5) as to the frequency of the event type to the ENSO phase. Otherwise, climate predictions are limited to 30 days and weather forecasts are limited to 7-10 days. Severe storms and their associated wind, snow and flooding effects will occur in Washington State regularly.

Figure 5.7-5



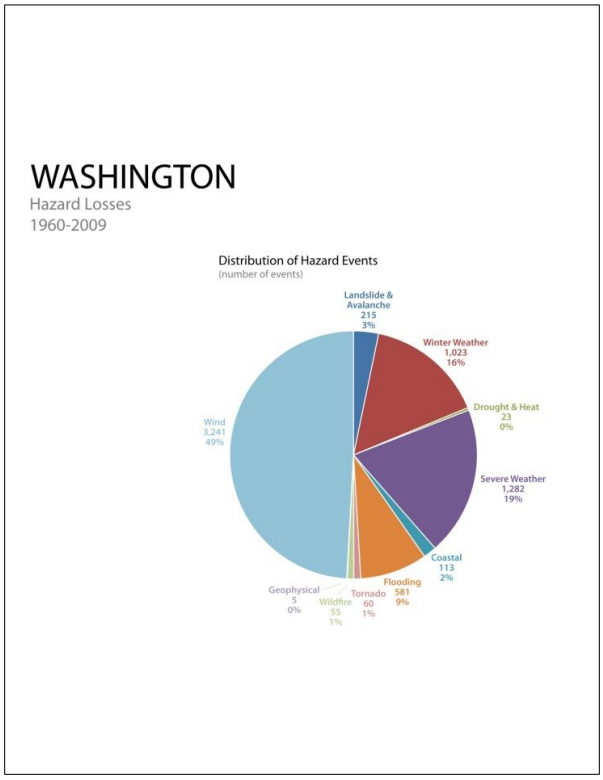
Jurisdictions Most Vulnerable to Severe Storms

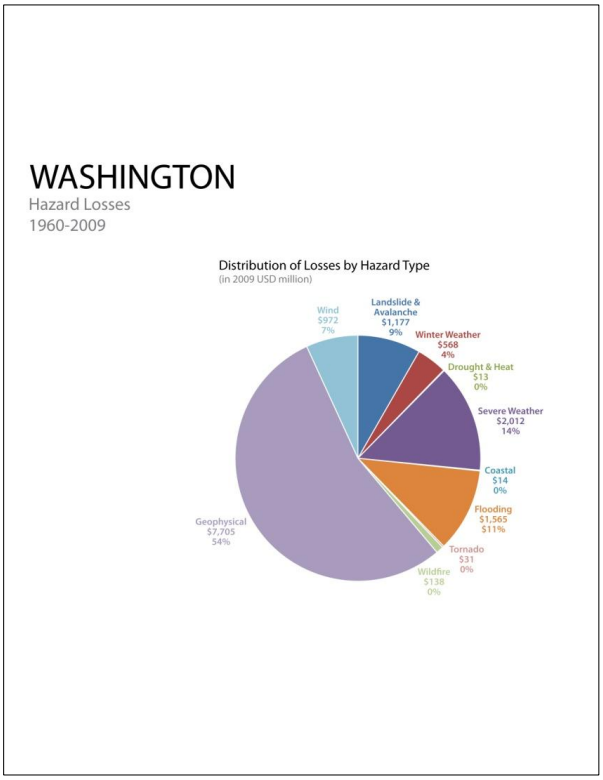
For the State Hazard Mitigation Plan, factors used to determine which counties are most vulnerable to a future non-flood, severe storm are:

- Counties most vulnerable to the non-flood meteorological criteria below, as determined by the Warning Coordination Meteorologist s from the National Weather Service whose offices oversee areas within Washington State.[32]
- How often severe storm events occur, expressed as a percentage of recurrence per year. The percentage used to differentiate jurisdictions most vulnerable differs by storm type and is explained below.

Data for frequency of severe storm events was obtained from the Special Hazard Events and Losses Database for the United States (SHELDUS, beta version), developed by the Hazard Research Lab at the University of South Carolina, and from the National Climatic Data Center of the National Oceanic and Atmospheric Administration. SHELDUS uses a variety of NOAA data sources. It covers severe weather events from 1960 through 2009 that caused more than $50,000 in property and/or crop damage. Data obtained from the National Climatic Data Center covered weather events causing more than $100,000 in property and/or crop damage from 1993 through 2012 (except June and July 1993, for which data is not available), with the following exceptions: Tornado information is from 1950 to 1992 and Thunderstorm wind and hail information is from 1955 to 1992. Analysis of the data sets eliminated duplicate entries between the SHELDUS and National Climatic Data Center data. Figure 5.7-6 shows the hazard losses from 1960 to 2009.

Figure 5.7-6





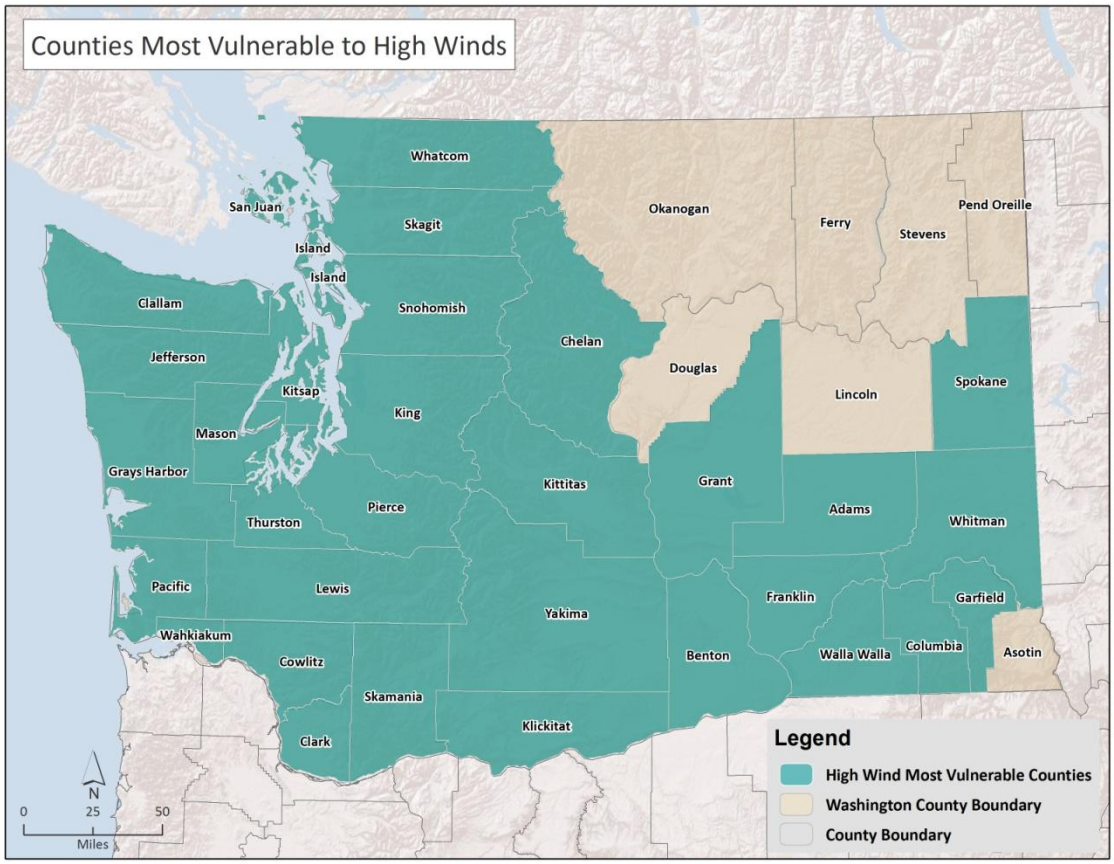
Source: SHELDUS (http://webra.cas.sc.edu/hvri/products/sheldusmaps.aspx)

The severe storm events for each county's vulnerability include high winds and winter storm history.

High winds – The National Weather Service defines high winds as sustained winds of 40 mph or gusts of 58 mph or greater, not caused by thunderstorms, expected to last for an hour or more. Areas most vulnerable to high winds are those affected by a strong pressure difference from deep storms originating over the Pacific Ocean; an outbreak of very cold, Arctic air originating over Canada; or strong air pressure differences between western and eastern Washington that primarily affect the Columbia River Gorge, Cascade Mountain passes, ridges and east slopes, and portions of the Columbia Basin.

Counties considered most vulnerable to high winds are 1) those most affected by conditions that lead to high winds, as described above, **and** 2) those with a high wind recurrence rate of 100 percent, meaning the county experiences at least one damaging high wind event every year. Several counties were added to the most vulnerable list for the 2013 plan update. These include Klickitat (strong east wind Gorge events), and many counties east of the Cascades such as Franklin, Grant, Adams, Whitman, and Garfield. Counties that meet both criteria, or were recommended for inclusion by the Warning Coordination Meteorologists for the National Weather Service, are highlighted in Figure 5.7-7 and in Table 5.7-1, page 14.

Figure 5.7-7



Winter storm – The National Weather Service defines a winter storm as having significant snowfall, ice, and/or freezing rain; the quantity of precipitation varies by elevation. Heavy snowfall is 4 inches or more in a 12-hour period, or 6 inches or more in a 24-hour period in non-mountainous areas; and 12 inches or more in a 12-hour period or 18 inches or more in a 24-hour period in mountainous areas.

Areas most vulnerable to winter storms are those affected by convergence of dry, cold air from the interior of the North American continent, and warm, moist air off the Pacific Ocean. Typically, significant winter storms occur during the transition between cold and warm periods.

Counties considered most vulnerable to winter storm are 1) those most affected by conditions that lead to such storms, as described above, and 2) those with a recurrence rate of 50 percent, meaning the county experiences at least one damaging winter storm event every two years. Several Counties were added during the 2013 plan update. These include Whatcom (very vulnerable given the proximity to the Fraser river canyon 'nor'easters'), Skagit, San Juan, Lewis and Kitsap Counties. Counties that meet both criteria, or were recommended for inclusion by the Warning Coordination Meteorologists for the National Weather Service, are highlighted in Figure 5.7-8 and in Table 5.7-1, page 14.

Nonetheless, because of Washington State's location on the windward coast of the Northern Pacific Ocean, along with its mountainous topography, which influences precipitation patterns, Washington State is assured of powerful severe storm events in the future. With the risk of severe storms impacting many Washington counties with significant populations, personal preparedness along with city and local

preparedness planning for severe storm events may be able lessen the impact to individuals and local jurisdictions when the next severe storm occurs.

Figure 5.7-8

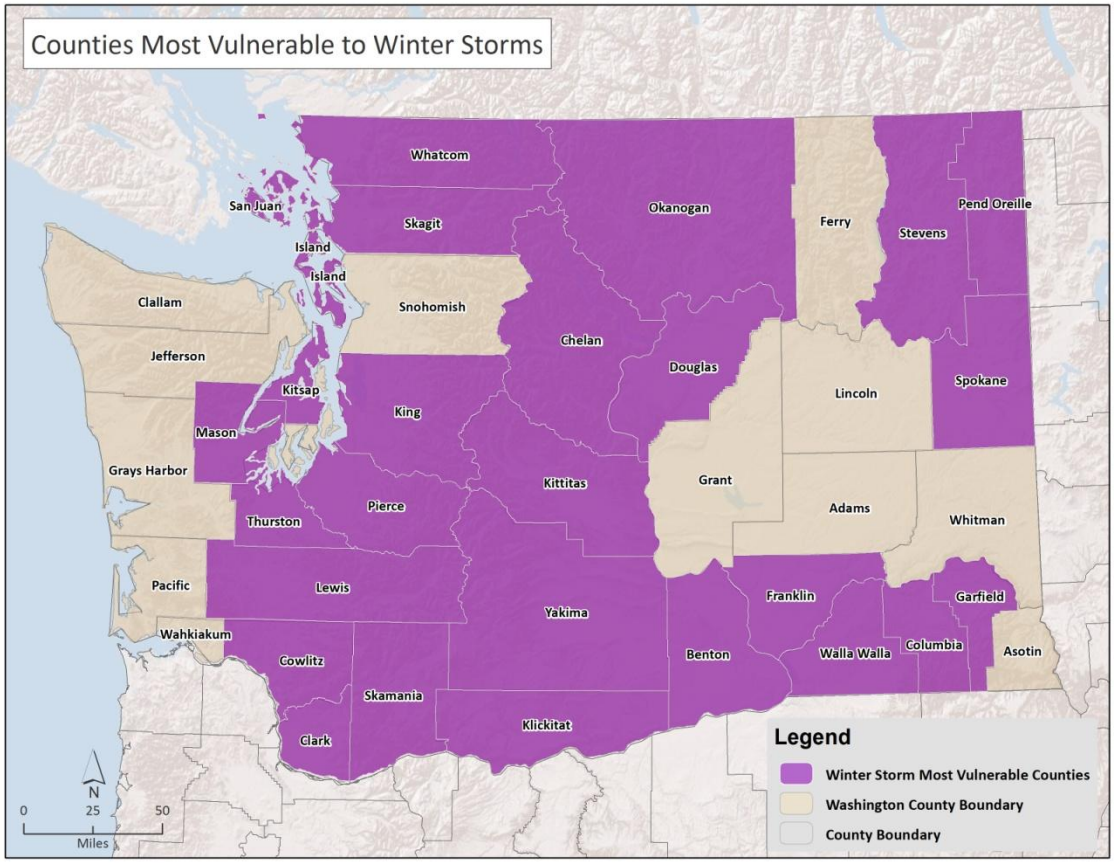


Table 5.7-1	Counties Most Vulnerable to High Winds (shade indicates most vulnerable)		Counties Most Vulnerable to Winter Storm (shade indicates most vulnerable)	
Counties (shaded for most vulnerable)	Vulnerable to Meteorological Conditions	Recurrence Rate (>100% – At least 1 occurrence per year)	Vulnerable to Meteorological Conditions	Recurrence Chance / Year (>50% – At least one occurrence every two years)
Adams	YES	70%, Included by NWS	NO	35%
Asotin	NO	70%	YES	23%
Benton	YES	140%	NO	48%
Chelan	YES, East Slopes of Cascades	Included by NWS	YES	Included by NWS
Clallam	YES, Pacific Coast	118%	YES	48%
Clark	YES	130%	YES, East County	85%
Columbia	YES	120%	YES	38%
Cowlitz	YES	113%	YES	60%
Douglas	NO	80%	YES	143%
Ferry	YES, Higher Elevations	65%	YES	23%
Franklin	YES	80%, Included by NWS	NO	33%
Garfield	YES	70% Included by NWS,	YES	73%
Grant	YES	93%, Included by NWS	NO	60%
Grays Harbor	YES	170%	NO	40%
Island	YES	148%	NO	43%
Jefferson	YES, Pacific Coast	125%	YES	43%
King	YES	133%	YES	70%
Kitsap	YES	125%	YES	35%, Included by NWS
Kittitas	YES	110%	YES	110%
Klickitat	YES	73%, Included by NWS	YES	38%
Lewis	YES	123%	YES	33% Included by NWS,
Lincoln	YES	75%	YES	25%
Mason	YES	165%	YES	60%
Okanogan	YES	83%	YES	128%
Pacific	YES, Pacific Coast	213%	NO	33%
Pend Oreille	YES	73%	YES	Included by NWS
Pierce	YES	165%	YES	60%
San Juan	YES, Western Half	173%	YES	48%, Included by NWS
Skagit	YES	188%	YES	58%, Included by NWS
Skamania	YES	95%	YES	88%
Snohomish	YES, Western Half	175%	YES	58%
Spokane	YES	105%	YES	55%
Stevens	YES, Higher Elevations	83%	YES	Included by NWS
Thurston	YES	175%	YES	50%
Wahkiakum	YES	118%	NO	35%
Walla Walla	YES	90%	YES	98%
Whatcom	YES, Western Half	190%	YES	65%, Included by NWS
Whitman	YES	93%, Included by NWS	YES	30%
Yakima	YES	103%	YES	73%

Potential Climate Change Impacts[33] [34,35, 36,37,38, 39]

With weather patterns drawing much of their dependence and rate of occurrences on the climate of a given area, it is only fitting to address the impacts that global climate change may have to severe weather incidents. According to climate models done by the University of Washington's Climate Impacts Group, the rate of temperature change will increase in the Pacific Northwest as will the amount of temperature change. They predict an average rate of warming of 5 degrees Fahrenheit per decade through 2050 and an average annual temperature increase of 2 degrees Fahrenheit. Seasons on average will all be warmer than previously experienced and the average annual temperature will likely exceed the range of the 20th century variability in the next 30 years in the Pacific Northwest. Precipitation in the Pacific Northwest is expected to increase by 1 to 2%, with more than half of the climate models projecting this increase in the winter (December-February) months and a large percentage of this precipitation will fall as rain rather than snow due to warmer winter temperatures.

Changes in the behavior of climate patterns such as El Niño and La Niña that effect storms in Washington are not well modeled. Thus, there is insufficient information in order to make a prediction as to how climate change will affect these sources of inter-annual climate variability in the Pacific Northwest. While severe storms have impacted every corner and jurisdiction in the State, counties at most risk of a future severe storm event include those counties along the Pacific Ocean, counties located within the Puget Sound basin, counties along the eastern slopes of the Cascade Mountains, and the southeastern counties of Benton, Walla Walla, and Columbia counties, as well as Spokane County.

Vulnerability to severe storm hazards is a function of location, type of human activity, use, and frequency of storm events. The effects of severe storms on people and structures can be lessened by total avoidance of flood hazard areas or by restricting, prohibiting, or imposing conditions on hazard-zone activity. Local governments can reduce flooding, landslides and wind effects through land-use policies and regulations. Individuals can reduce their exposure to hazards by educating themselves on the past history of a site and by making inquiries to planning and engineering departments of local governments. In addition, it is highly advised to consult the professional services of an engineering geologist, geotechnical engineer, or a civil engineer, who can properly evaluate a site, built or un-built.

Coastal flooding is also a concern in Washington with the rise in sea level because of global ocean warming. As global temperature rise, oceans expand and ice melts, causing the water level to rise. The State of Washington has over 3,000 miles of marine coastline. The United Nation's Intergovernmental Panel on Climate Change (IPCC) reports that from 1993 to 2003, global sea level rose about 3 millimeters (approximately 0.12 inches) each year, and approximately half of that increase is attributed to the ocean expanding as it warms. While a sea rise of a few millimeters may seem insignificant, Carol Auer, an Oceanographer with the National Oceanic and Atmospheric Administration (NOAA) says, "A half-inch of vertical sea level rise translates to about three feet of land lost on a sandy open coast, due to long term erosion. Moreover, even a slightly higher sea level can cause more dramatic deltas and estuary tides. Rising sea levels also make coastal areas more vulnerable to storm surges, and in turn, to flooding".

The State of Washington Department of Ecology addresses Sea Level Rise as well. They cite a 2012 National Research Council report titled *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past Present and Future. The report predicts a 24 inch rise for the West Coast by 2100, with a range of 4 to 56 inches.* Essentially, more land and thus people and structures are vulnerable to the hazard. The Department of Ecology has also laid out a strategy to reduce losses and determine risk to the hazard.

According to a 2005 Governor's report prepared by the Climate Impacts Group titled *Uncertain Future: Climate Change and its Effects on Puget Sound*, from "paleoclimatological evidence, we know that over the history of the earth high levels of greenhouse gas concentrations have correlated with, and to a large extent caused, significant warming to occur, with impacts generated on a global scale." While the report also indicates that the "ultimate impact of climate change on any individual species or ecosystem cannot be predicted with precision," there is no doubt that Washington's climate has demonstrated change.

In July 2007, the Climate Impacts Group launched an unprecedented assessment of climate change impacts on Washington State. *The Washington Climate Change Impacts Assessment* (WACCIA) involved developing updated climate change scenarios for Washington State and using these scenarios to assess the impacts of climate change on the following sectors: agriculture, coasts, energy, forests, human health, hydrology and water resources, salmon, and urban stormwater infrastructure. The assessment was funded by the Washington State Legislature through House Bill 1303.

In 2009, the Washington State Legislature approved the *State Agency Climate Leadership Act* Senate Bill 5560. The Act committed state agencies to lead by example in reducing their greenhouse gas (GHG) emissions to: 15 percent below 2005 levels by 2020; 36 percent below 2005 by 2035; and 57.5 percent below 2005 levels (or 70 percent below the expected state government emissions that year, whichever amount is greater.). The Act, codified in RCW 70.235.050-070, directed agencies to annually measure their greenhouse gas emissions, estimate future emissions, track actions taken to reduce emissions, and develop a strategy to meet the reduction targets. Starting in 2012 and every two years thereafter, each state agency is required to report to Washington State Department of Ecology the actions taken to meet the emission reduction targets under the strategy for the preceding biennium.

Recognizing Washington's vulnerability to climate impacts, the Legislature and Governor Chris Gregoire directed state agencies to develop an integrated climate change response strategy to help state, tribal and local governments, public and private organizations, businesses and individuals prepare. The state Departments of Agriculture, Commerce, Ecology, Fish and Wildlife, Health, Natural Resources and Transportation worked with a broad range of interested parties to develop recommendations that form the basis for a report by the Department of Ecology: *Preparing for a Changing Climate: Washington State's Integrated Climate Change Response Strategy*.

Over the next 50 - 100 years, the potential exists for significant climate change impacts on Washington's coastal communities, forests, fisheries, agriculture, human health, and natural disasters. These impacts could potentially include increased annual temperatures, rising sea level, increased sea surface temperatures, more intense storms, and changes in precipitation patterns. Therefore, climate change has the potential to impact the occurrence and intensity of natural disasters, potentially leading to additional loss of life and significant economic losses. Recognizing the global, regional, and local implications of climate change, Washington State has shown great leadership in addressing mitigation through the reduction of greenhouse gases.

Some suggest that there is a better way to deal with floods: the "soft path" to flood risk management. The "soft path" strategy to flood management takes into account the fact that floods will happen and to learn to deal with them the best way possible. This strategy is also based on an understanding that flooding is essential for the health of riverine ecosystems. A "soft path" approach means taking measures to reduce the speed, size and duration of floods by restoring meanders and wetlands…." This approach "also means doing all we can to get out of floods' destructive path with improved warning and

evacuation measures. Such practices are already in use in some parts of the United States and around the world. Improving our ability to cope with floods requires adopting a more sophisticated set of techniques. The "soft path" of flood management should be a core part of efforts to adapt to a changing climate. Such a strategy may reduce deaths due to flooding and could result in much healthier rivers and streams. This philosophy can be expanded to include the other effects of severe storms.

At Risk State Facilities

This profile will not attempt to estimate potential losses to state facilities due to severe storm. The state does not have data on which to base a determination of which facilities might be most vulnerable to either high winds or winter storm events. However, all facilities are considered vulnerable to this hazard.

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